MAGNETIC RESONANCE MONITOR FOR ^{99}TECHNETIUM COLUMN BREAKTHROUGH

TECHNOLOGY NEEDS

In support of Phase 1 Privatization initiatives at Hanford to remove technetium-99 (^{99}Tc) from radioactive liquid waste, a non-radiometric sensor technology that is capable of accurately monitoring ^{99}Tc is required. This technology will provide real-time, on-line monitoring of ion exchange or adsorption column breakthrough. The sensor also supports other separation techniques by monitoring both inlet and outlet for technetium content in process streams. Furthermore, the sensor is also ideal for on-line monitoring of tank effluents. Sensor requirements include operation in a high-radiation background, operation at high pH, operation in high concentrations of dissolved salts (nitrates), and sensing without radiometric methods. The technology must provide sufficient sensitivity, dynamic range, reproducibility, and accuracy to characterize ^{99}Tc at the 10 –1,000 micro-Curies per liter range (15 to 1,500 micromolar range). In addition, the sensor must be sufficiently robust and intelligent to operate independently for prolonged periods (6 months to years). Finally, the system must be reasonably economical and sufficiently developed as to be implemented in a plant environment.

TECHNOLOGY DESCRIPTION

The on-line nuclear magnetic resonance (NMR) process monitor under development will ideally meet the ^{99}Tc monitoring needs of the Tank Focus Area. NMR is a non-contact, non-destructive, quantitative analytical technique. The technique is reasonably sensitive and has a wide linear response over a concentration range from parts-per-million (PPM) to 100%. The technique employs pulsed radio frequency (RF) waves in the 100 MHz region to examine the nuclear spin of the isotopes of interest. Unlike optical or electro-chemical analytical techniques, NMR instrumentation will not have any interference due to its window or electrode coating, and NMR instrumentation is generally immune to variations in the sample matrix, and interference from other chemicals or isotopes. NMR is also immune to highly radioactive backgrounds and harsh operating conditions.

BENEFITS

Continuous on-line technetium monitoring will provide the ability to monitor effluent streams from separation columns, tank concentrations, and plant effluents. This monitoring provides automated real-time analysis of technetium and sodium, which results in considerable cost savings for laboratory analyses. Furthermore, the ability to monitor wastes in real time safeguards the health of both workers and the public by guarding against accidental release of materials.

CAPABILITIES/LIMITATIONS

It has also been shown that ^{99}Tc is an ideal isotope for analysis and process monitoring via magnetic resonance. The species is 100% isotope abundant, and it is the fifth most sensitive isotope to the magnetic resonance phenomena. The isotope also has a fast nuclear relaxation time, allowing analysis measurements to be performed in near real time (i.e., analysis in the millisecond range). Moreover, the high isotopic spin number of 9/2 provides spectroscopic peaks with narrow line-widths that are easily detected. Given that the isotope relaxation times are very fast, and that the isotope has 40% of the NMR sensitivity of hydrogen, it is little wonder that early magnetic resonance studies have shown that signals are easily detected and narrow lines are observed.

COLLABORATION/TECHNOLOGY TRANSFER

Argonne National Laboratory (ANL) is actively pursuing installation of this technology at Hanford and is continuing technical discussions with the privatization partners. Furthermore, ANL has a similar and

related Cooperative Research and Development Agreement (CRADA) with Oxford Instruments for the manufacturing of this technology. Several patent disclosures have been generated at ANL in this area.

ACCOMPLISHMENTS

The ANL intelligent process control NMR monitor is designed to weigh approximately 150 pounds (dominated by the weight of its magnet). The cost of the NMR monitor ranges between $20,000 to $30,000 per unit, and it placed on a short 19-inch NEMA 4 industrial instrumentation rack. The system has been programmed with advanced heuristics, and is capable of complete automation without human interaction for long periods (6 months to years). The system is operated using a simple graphic user interface. The system has demonstrated sensitivity to 25 micromolar with a 10-minute analysis. Furthermore, the system will be capable of performing full oxidation of technetium to pertechnetate for a complete technetium analysis.

TECHNICAL TASK PLAN (TTP) INFORMATION

TTP No./Title: CH27C231 - Development of a Nuclear Magnetic Resonance Monitor for Technetium-99 Column Breakthrough

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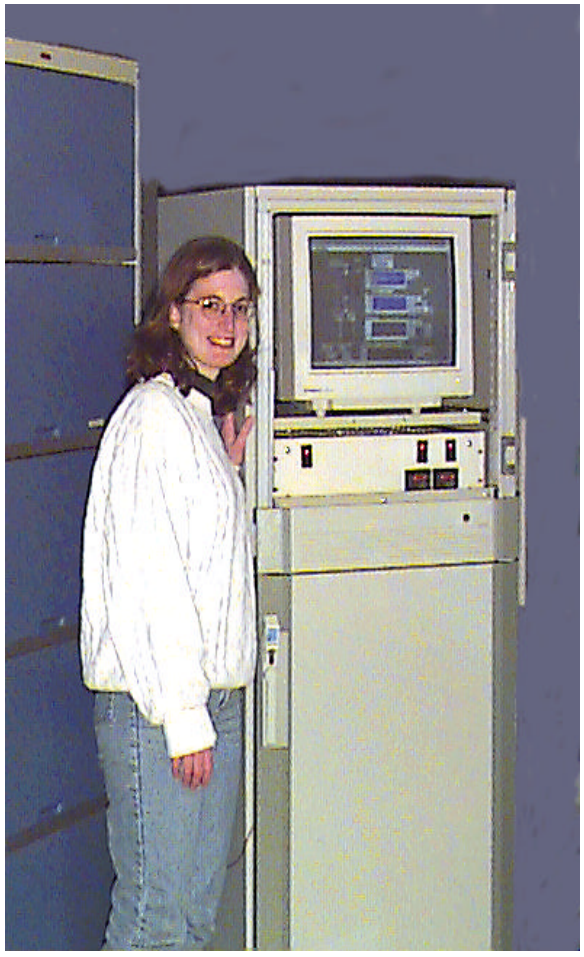
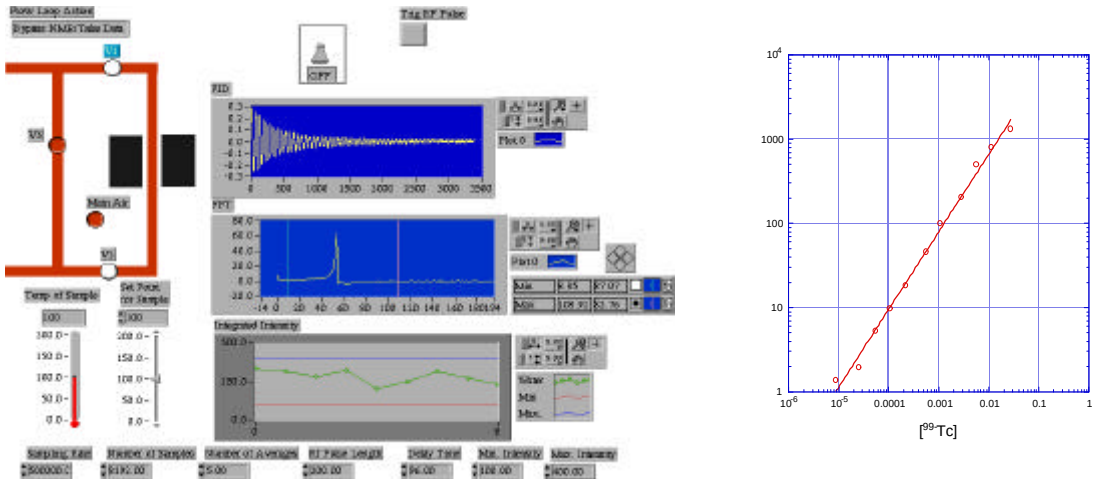


Computer display panel of the nuclear magnetic resonance technetium-99 on-line monitoring system (with monitor door removed).



Graphic User Interface for on-line nuclear magnetic resonance controller, and resulting output plot demonstrating micromolar sensitivity and wide linearity of response.